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PREVENTING INJURY FROM JAPANESE AND ASIATIC BEETLE LARVAE TO TURF IN PARKS AND OTHER LARGE AREAS

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INTRODUCTION

The larvae, or grubs, of the Japanese beetle (*Popillia japonica* Newman), the Asiatic garden beetle (*Autoserica castanea* Arrow), and the oriental beetle (*Anomala orientalis* Waterhouse), which have become established at several localities in the eastern part of the United States, feed on the roots of grass, and, where abundant, cause severe damage to the grass in lawns, parks, and golf courses. Research has been carried on for several years to develop methods of protecting turf from ravages of these insects. The results of these investigations have been published as the work progressed and further information was obtained (*1*, *3*, *5*, *7*, *8*, *9*, *10*).[2] This circular is designed primarily to furnish interested persons with a means of identifying these larvae and to supply the latest information on the most satisfactory procedures for protecting turf from injury.[3] It supersedes Circular 238, which is out of print.

APPEARANCE AND HABITS OF THE LARVAE

The larvae of these beetles are similar in appearance to native white grubs. They may be described as short, more or less stout, blunt-ended grubs of a creamy or whitish color, with yellowish or

[1] This circular is a revision of and supersedes Circular 238, Control of Larvae of the Japanese and the Asiatic Beetles in Lawns and Golf Courses.
[2] Italic numbers in parentheses refer to Literature Cited, p. 10.
[3] Suggestions to householders for the protection of small lawns are given by Fleming and Metzger (*2*).

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brownish heads and with a slight covering of hair. Three pairs of short legs are attached to the anterior quarter of the larva on the ventral side. In its usual position—when not crawling—the larva lies curled in the form of a horseshoe. The appearance of a fully developed larva of the Japanese beetle is shown in figure 1. The

FIGURE 1.—Full-grown larva of the Japanese beetle. About five times natural size.

larvae of the Japanese beetle and the other introduced species can be distinguished from the native species which are frequently associated with them by the arrangement of the spines and hairs, called the raster, on the ventral surface of the terminal posterior segment, as shown in figure 2.[4]

The larvae of the Japanese and Asiatic beetles feed on the roots of grass immediately below the surface of the ground. The depth at which the larvae feed during the active season is dependent upon the moisture in the soil. When the soil is moist, the larvae are close to the surface, but when the upper layer of the ground is dry, they burrow downward until soil having a satisfactory degree of moisture is reached. As cold weather approaches, the larvae burrow deeper into the ground, where they remain inactive during the winter. In the spring they return to the surface, feed for a few weeks, and then,

[4] Further information on the characters useful in identifying these larvae is given by Sim (*11*).

after going through a brief resting stage, transform into adult beetles.[5]

During summers of normal rainfall, when the grass retains a uniform green color, the larvae of these beetles are usually evenly distributed in the turf, but in dry summers they are generally found in the more moist portions of lawns and in the greens on golf courses. These larvae are only rarely found in large numbers in sod which is shaded for the greater part of the day, but usually occur in abundance in open grasslands.

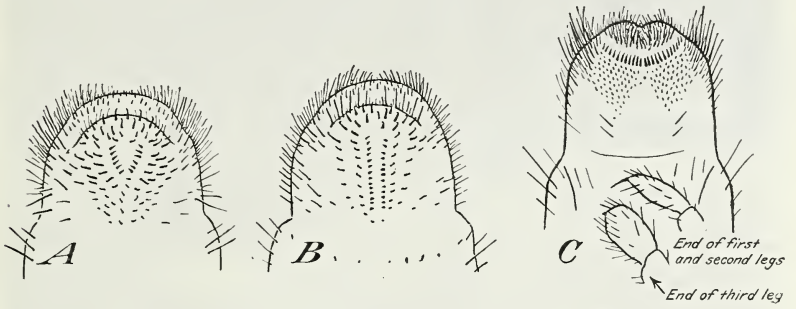

FIGURE 2.—Underside of last abdominal segment of the Japanese beetle larva and of closely related species, illustrating the differences in the arrangement of the hairs and spines. *A*, Japanese beetle; *B*, oriental beetle; *C*, Asiatic garden beetle.

NATURE OF INJURY BY LARVAE TO GRASS

Injury done to lawns and golf courses by the larvae of these beetles usually becomes apparent late in the summer and early in the fall, and it may be very noticeable late in fall and in spring. The density of the larval population sufficient to cause damage to turf is not a fixed quantity but is modified by the type of grass, the condition of the soil, the amount of moisture, the availability of plant food, and other factors of a favorable environment. As grass may be damaged by unfavorable conditions, disease, and other insects, the presence of larvae of the Japanese or Asiatic beetles in the turf should be definitely established before the condition of the turf is attributed to them. If a portion of the sod is examined and a number of these larvae are found, it may be safely concluded that they are causing the damage.

The appearance of grass suffering from injury by these beetles is similar, in the early stages, to that of grass retarded by an inadequate supply of moisture or nutrients. When the root system is damaged by the feeding of these larvae, the grass may not be able to draw a sufficient supply of nutrients and moisture from the soil to maintain a good sward. As injury becomes more extensive, the aerial portion of the grass is often completely severed from the roots, and the turf can be easily rolled back with the fingers. Turf which has been killed in this manner is shown in figure 3. A lawn or golf

[5] Further information on the life history and habits of these beetles is given by Hadley and Hawley (4) and Hallock (5, 6).

course seriously damaged by these larvae is soft and spongy because of the extensive burrowing of the insects immediately beneath the surface of the ground.

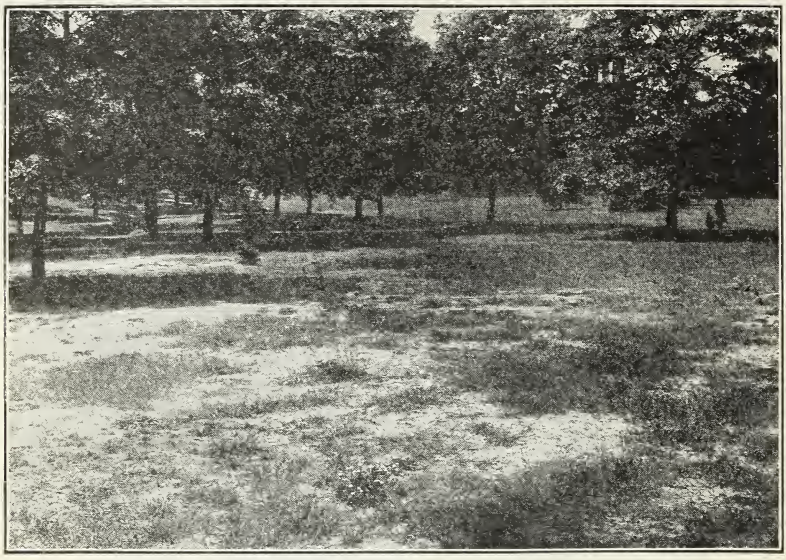

FIGURE 3.—Turf injured by larvae of the Japanese beetle.

HOW LEAD ARSENATE KILLS LARVAE

As the larvae take soil into the alimentary system while feeding and burrowing, the incorporation of a stomach-poison insecticide such as lead arsenate is a logical and effective method of control. The time required for a larva to consume a fatal dose of lead arsenate depends upon the activity of the insect and the concentration of the poison in the soil. It is apparent that the greater the concentration of the insecticide in the soil, the shorter the distance the larva can burrow and the less it can feed on roots before obtaining a fatal dose. If there is only a small quantity of the arsenical in the soil, it is possible for the larva to do considerable feeding before ingesting a sufficient quantity of the poison to kill it. Under favorable conditions, several weeks may elapse before the insects are destroyed. The larvae, however, feed very little after the arsenic begins to affect them, and soon become flabby and discolored.

As the lead arsenate is distributed only through the upper layer of soil, some larvae may continue to live for several months before consuming a fatal dose of the poison, because they have remained most of the time below the poisoned layer. However, larvae which are not within 3 inches of the surface, where most of the grass roots and the poison are found, can cause little damage to turf.

QUALITY OF LEAD ARSENATE REQUIRED

Lead arsenate which satisfies the standard requirements of the chemical used as an agricultural spray is satisfactory for the treatment of turf. It should contain at least 30 percent of arsenic pentox-

ide (As_2O_5) and not more than 0.75 percent of water-soluble arsenic, expressed as metallic arsenic. The material should be purchased in the powder form in bags or drums of convenient sizes. Stickers should not be added to the material because the success of the treatment is dependent upon getting the chemical into the ground; the addition of a sticker will increase the adherence of the material to the aerial portion of the grass.

PROTECTION OF ESTABLISHED TURF FROM INJURY

It is better to protect turf from injury by the larvae of these beetles by preventing them from becoming established in sufficient numbers on a lawn or golf course to cause damage, than to attempt to save the grass after damage has occurred. When the adult Japanese beetle is causing pronounced damage to the foliage of shade trees and shrubs, or when it is known that the oriental beetle or the Asiatic garden beetle is present in the vicinity, periodic examinations of the turf should be made each year early in the fall to determine whether infestation is becoming established in the grass. The following procedure has been found satisfactory in making a methodical examination of sod to determine the larval population: A square foot of turf is cut on three sides to a depth of 2 to 3 inches with a spade, the spade is then forced beneath the sod at this depth from the side opposite the uncut margin, and the sod is laid back, using the uncut side as a hinge. The exposed soil is then examined to a depth of 2 inches. The soil about the roots of the overturned grass is next carefully removed with a sharp trowel, such as a pointing trowel, to dislodge any larvae that are among the roots. After the number of larvae has been determined, the sod is replaced and the process is repeated at other spots until a sufficient area has been examined to establish the status of the infestation.

When several larvae of these beetles are found in the turf, it should be treated as soon as possible with lead arsenate at the rate of 10 pounds to 1,000 square feet. As the number of larvae necessary to cause damage is a variable factor which is modified by the local conditions, the presence of a small number should be taken as a warning of potential damage. The prompt application of lead arsenate will reduce the infestation in the turf to negligible proportions and will assure destruction of subsequent invasions for a period of several years.

QUANTITY OF LEAD ARSENATE TO APPLY

The larvae of these beetles can be destroyed in turf by the application of *lead arsenate at the rate of 10 pounds to 1,000 square feet.* The application of smaller quantities of the insecticide will be of some value in reducing the density of the larval population, but under some conditions has not afforded satisfactory protection to the turf. It cannot be emphasized too strongly that the effectiveness of the treatment is dependent upon having a poisoned layer of soil over the whole surface of sufficient concentration to kill the larvae.

It is a general practice to top-dress greens on golf courses and the better turf in parks at least once a year, and sometimes two or three times a year if the soil is being improved, with a compost of soil and manure or other suitable material. As it is necessary to avoid

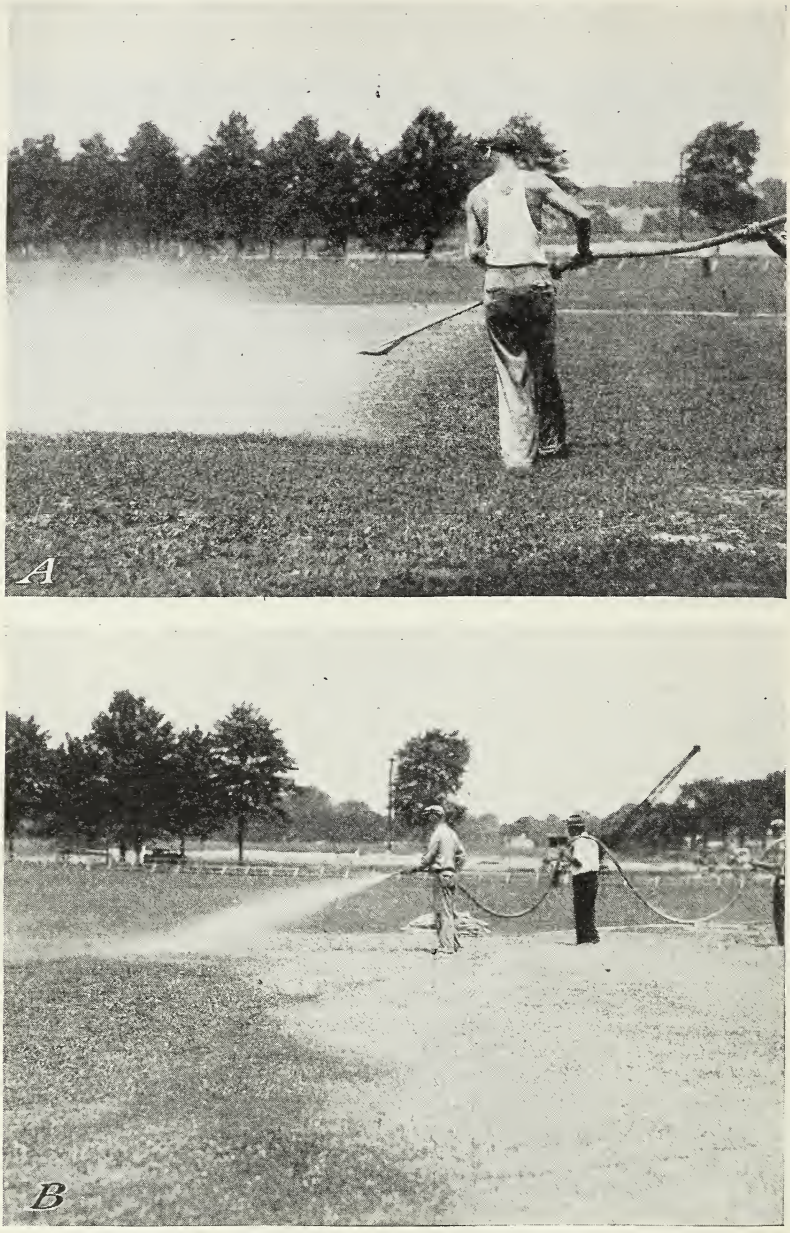

FIGURE 4.—Applying lead arsenate as a spray: *A*, Applying the spray; *B*, washing with water.

establishing a layer of unpoisoned soil near the surface of the ground, it is advisable to mix lead arsenate with each top dressing at the rate of 2 pounds to each cubic yard.

METHODS OF APPLYING LEAD ARSENATE

The small quantity of lead arsenate recommended must be diluted to obtain a uniform distribution. It is largely a matter of choice whether the chemical is applied in water, or in a dry state mixed with sand, soil, or other material, because both methods of application have been found to be equally effective.

In applying the lead arsenate with water by means of a power sprayer capable of developing 200 to 300 pounds of pressure, it should be mixed with the smallest possible volume of water in order to obtain a uniform distribution without flooding the turf. Satisfactory results have been obtained with a mixture containing 1 pound of lead arsenate to 2 gallons of water, and in some cases with a concentration of 1 pound to 1 gallon. The use of these relatively large quantities of material with water necessitates sufficient agitation to keep the material properly suspended in the spray tank. A Worthley nozzle with a baffle, used with a pressure of 200 to 300 pounds, has given a good distribution of the chemical. A power sprayer is usually too heavy to take on the turf, so it must be placed in an advantageous position, and one or more lines of hose laid to the area to be treated. The man at the nozzle begins to apply the spray at the point most remote from the sprayer, assisted by as many men as are required to keep the heavy hose and hose connections from dragging on the turf. When mixed at a concentration of 1 pound to 2 gallons of water, 20 gallons of spray should be applied to 1,000 square feet; when mixed at the rate of 1 pound to 1 gallon, 10 gallons of spray should be applied to 1,000 square feet of surface. With a little experience, a man can adjust his gait to the rate at which the spray is flowing, so that the required quantity will be applied. After the spray is applied, the turf should be well washed with water to remove the material from the grass before it dries. If the washing operation is delayed until the spray has dried, it is difficult to remove the material. The application of lead arsenate as a spray to the grass and the washing of the material into the soil are shown in figure 4.

Many people prefer to mix lead arsenate with a filler and apply it in a dry state because this method does not require expensive equipment. Several relatively inexpensive distributors, similar in type to the one shown in figure 5, are now available on the market. When the mixture is applied in a distributor, it must be finely ground, dry, and free from any tendency to clog. The most satisfactory of the lead arsenate mixtures, of those tested for application in a distributor, are as follows:

(1) 1 part of lead arsenate, 4 parts of activated sludge, by weight.
(2) 1 part of lead arsenate, 2 parts of activated sludge, 4 parts of bar sand, by weight.
(3) 1 part of lead arsenate, 2 parts of tankage, 4 parts of bar sand, by weight.
(4) 1 part of lead arsenate, 10 parts of bar sand, by weight.

It is possible to prepare these mixtures some time before applying them to turf, but it is advisable to mix them only a short time

before they are to be used, because in some cases it has been found that the mixtures become somewhat lumpy after being in storage and cannot be distributed satisfactorily in the machine. Of course, when there is only a small area to be treated, the chemical may be mixed with about 25 times its volume of moist sand, soil, or other suitable material, and broadcast by hand. The above-mentioned mixtures have been applied to turf as top dressings without causing injury. When inorganic fertilizers were applied with the lead arsenate some superficial damage to the aerial portion of the grass occurred. Although the injury caused by the addition of inorganic fertilizers was only temporary, it is advisable to exclude these materials from the mixture containing lead arsenate. Although lead arsenate in the dry form does not adhere readily to grass, enough of the material often remains on the grass to be an annoyance to

FIGURE 5.—Applying lead arsenate in the dry form with a distributor.

golfers and to be a hazard to children and domestic animals. It is advisable, therefore, to wash the turf with water after the treatment has been completed.

PRECAUTIONS IN THE APPLICATION OF LEAD ARSENATE

As is well known, lead arsenate is poisonous to man and animals, and, consequently, care should be exercised in its use. Particular care should be taken in handling the dry material in order to avoid inhaling the dust. Lead arsenate, while primarily a poison of the digestive system, is known to cause disturbances to those who expose themselves recklessly to the dust. It may be mixed and otherwise manipulated with the bare hands, but, since there is a pos-

sibility that the poison may be absorbed into the system through cuts and abrasions of the skin, it is advisable to protect the hands. The worker should keep the hands away from the mouth and wash them thoroughly before eating.

CARE OF TURF AFTER TREATMENT

After the lead arsenate has been applied, either as a spray or in the dry state, to turf, the normal operations of mowing, watering, and fertilizing can be carried on as usual. Fertilizers such as well-rotted manure, ammonium sulphate, sodium nitrate, potassium chloride, superphosphate, bone meal, activated sludge, and tankage have been used successfully on treated turf. The inorganic fertilizers must be applied uniformly and at no higher rate of application than usually recommended, in order to avoid superficial damage to the grass. Lime should be used on poisoned turf only when necessary to correct the acidity of the soil. The addition of hydrated lime, or stone lime, except for the purpose mentioned above, is not recommended, because this material has been found to reduce the effectiveness of the insecticidal treatment.

REHABILITATION OF INJURED TURF

If the sod has not been treated, if the amount of lead arsenate previously applied to the soil was insufficient, or if the arsenical has been depleted by weathering, the turf should be treated as soon as injury becomes apparent. Lead arsenate can be applied at any time during the growing season. If the ruined portion of the grass is replaced with untreated sod, it is advisable to apply the lead arsenate to the newly placed sod after it has been set in position. If the injured portion is prepared for seeding, the chemical should be applied in the dry form and raked into the soil to a depth of 1 to 2 inches before the seed is sown.

TREATMENT OF NEWLY CONSTRUCTED LAWNS AND GREENS

When few larvae of these beetles are observed in the soil during the process of preparing the seedbed, it is advisable to have the grass well established before applying the lead arsenate. If the seedbed is prepared and the grass sown late in the summer or early in the fall, the lead arsenate should be applied the following spring, when the grass has become established, in order to have the material in the soil before the larvae of the succeeding generation appear. When many larvae are observed during the process of preparing the seedbed, it is necessary to apply the lead arsenate to the ground before seeding in order to prevent the larvae from destroying the grass as soon as it has germinated. In this case it is advisable to apply the lead arsenate in the dry form only, and to rake it in to a depth of 1 to 2 inches, at least 30 days before seeding, to kill a large proportion of the larvae before the grass germinates. Grass in poisoned soil is usually somewhat slower in germinating, the foliage is darker, and the growth is slower during the first few weeks than in unpoisoned soil. After the common grasses have become established on poisoned

soil, there is usually little difference in the appearance of the sward from that on unpoisoned soil.

DURATION OF THE EFFECTIVENESS OF THE TREATMENT

It is difficult to predict how long turf top-dressed with lead arsenate will remain immune to injury by the larvae of these beetles, as this will depend upon the type of grass, the density of the population of the beetles in the vicinity, the drainage, soluble salts present in the soil, the amount of organic matter, the depth of penetration of the poison, and other factors. It is believed that under average conditions one application of lead arsenate at the rate of 10 pounds to 1,000 square feet will protect turf from injury for at least 5 years. When the material is added annually with top dressings to the turf, it should be impossible for larvae to become established in the grass in sufficient numbers to cause injury.

The treatment of turf, of course, does not preclude the emergence of adult beetles during the summer from untreated areas and their subsequent flight to plants growing on or near the treated portions. The effectiveness of the treatment should not be judged by the presence of beetles on plants in the vicinity but entirely upon the condition of the treated grass.

TOLERANCE OF DIFFERENT GRASSES TO LEAD ARSENATE

It has been found that redtop (*Agrostis alba* L.), colonial bent (*A. tenuis* Sibth.), creeping bent (*A. palustris* Huds.) and the forms of this grass called Washington bent and Metropolitan bent, velvet bent (*A. canina* L.), Kentucky bluegrass (*Poa pratensis* L.), red fescue (*Festuca rubra* L.), perennial ryegrass (*Lolium perenne* L.), and Italian ryegrass (*L. multiflorum* Lam.) grow satisfactorily in ground containing lead arsenate. White clover (*Trifolium repens* L.) appears to be uninjured. Annual bluegrass (*Poa annua* L.), which may be classified as a troublesome weed, although it is commonly grown in shady places, is sometimes killed by lead arsenate.

EFFECT OF THE TREATMENT ON BIRDS AND ANIMALS

A treated lawn or golf course should not be injurious to birds, because they will not be attracted to it after the treatment has killed most of the worms and the larvae in the soil. The extensive use of lead arsenate on turf within the infested area has not caused any known damage to the native birds which feed on earthworms and larvae in the soil. There is no evidence to show that domestic animals have been poisoned by the application of lead arsenate to turf, when care was taken in applying the treatment as directed, and where unused portions of the material were carefully stored.

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